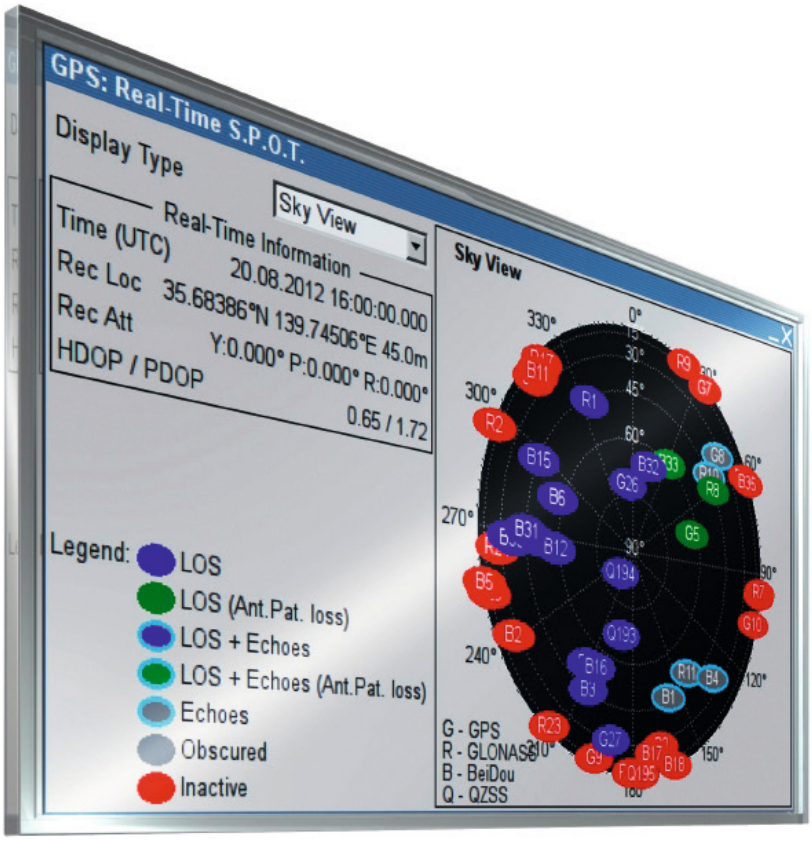
GNSS Simulator in the R&S®SMBV100A Vector Signal Generator

The new reference in satellite simulation



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Product Brochure | 06.00

GNSS Simulator in the R&S®SMBV100A

At a glance

Whether in the R&D lab or in production, the global navigation satellite system (GNSS) solution for the R&S®SMBV100A sets new standards in the field of satellite simulation. It supports all possible scenarios, from simple setups with static satellites all the way to flexible scenarios generated in realtime with up to 24 dynamic GPS, Glonass, Galileo, BeiDou and QZSS/SBAS satellites.

A number of standard tests are available for characterizing the performance of a GNSS receiver, e.g. time to first fix (TTFF) and location accuracy. Test runs often include an entire series of tests, each with a different scenario. Therefore, satellite simulators that allow users to simulate a wide variety of scenarios are ideal for this purpose.

This is where the flexibility of the GNSS solution for the R&S®SMBV100A stands out: Only a few keystrokes are needed to generate complex scenarios, unlimited in time, with up to 24 satellites – including hybrid GPS, Glonass, Galileo, BeiDou and QZSS/SBAS constellations. Users can select the almanac file as well as the geographic position, and both stationary positions and moving scenarios that simulate the movement of receivers along any custom route are possible. The signal strength of individual satellites can be controlled in realtime in order to simulate conditions of restricted satellite visibility.

The GNSS functionality provided by the R&S®SMBV100A also includes the ability to simulate realistic transmission and signal reception conditions through the use of multipath signal generation, by modeling various atmospheric effects and surroundings with buildings and bridges, or by simulating realistic vehicle dynamics.

The versatility of the R&S®SMBV100A is especially beneficial to mobile phone and car infotainment system manufacturers who integrate GNSS modules in their products, as it allows them to test a range of functions with a single instrument. This is possible because, in addition to GNSS signals, the R&S®SMBV100A also generates communications signals conforming to all conventional standards such as LTE, HSPA+ and WiMAX™ as well as signals for digital radio standards such as DAB, XM Radio or Sirius.

Key facts

- Support of GPS L1/L2 (C/A and P code), Glonass L1/L2, Galileo E1, BeiDou B1/B2 and QZSS/SBAS L1, including hybrid constellations
- Realtime simulation of realistic constellations with up to 24 satellites and unlimited simulation time
- Flexible scenario generation including moving scenarios, dynamic power control and atmospheric modeling
- Configuration of realistic user environments, including obscuration and multipath, antenna characteristics and vehicle attitude
- Static mode for basic receiver testing using signals with zero or constant Doppler shift
- Support of Assisted GNSS (A-GNSS) test scenarios, including generation of assistance data for GPS, Glonass, Galileo, BeiDou and QZSS/SBAS
- Realtime external trajectory feed for hardware in the loop (HIL) applications
- Logging of simulation data
- High signal dynamics [1], simulation of spinning vehicles and precision code (P code) simulations to support aerospace and defense applications
- Enhanced simulation capabilities for aerospace applications by supporting ground-based augmentation systems (GBAS)
- Support of other digital communications and radio standards in the same instrument

[1] May be subject to export restrictions.

GNSS Simulator in the R&S®SMBV100A

Benefits and key features

GNSS receiver tests made easy

- Flexible scenario generation facilitates receiver testing
- Faster testing with GNSS signal generation in realtime
- Static simulations with zero or constant Doppler shifts for rapid receiver prototyping and development
- Unlimited simulation time with automatic, on-the-fly exchange of satellites
- Support of Assisted GNSS (A-GNSS) test cases for GPS, Glonass, Galileo, BeiDou and QZSS/SBAS
- Aerospace and defense applications
- Support of hardware-in-the-loop applications through realtime external trajectory feed

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Simulation of real-world conditions

- Ensuring realistic conditions for receiver tests
- Simulation of atmospheric effects
- Customizable antenna characteristics
- Realistic vehicle dynamics, including attitude simulation
- Urban canyon simulations with multipath and signal obscuration
- Customizable land mobile multipath environment
- Configurable noise and interference simulation

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Customized solutions through flexible options

- Instrument configuration tailored to customer needs
- Ready for other GNSS standards
- Ideal for production and R&D alike

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GNSS simulation plus multifaceted vector signal generation

- Support of all important, state-of-the-art digital standards
- Customized internal signal generation
- High performance for all types of applications

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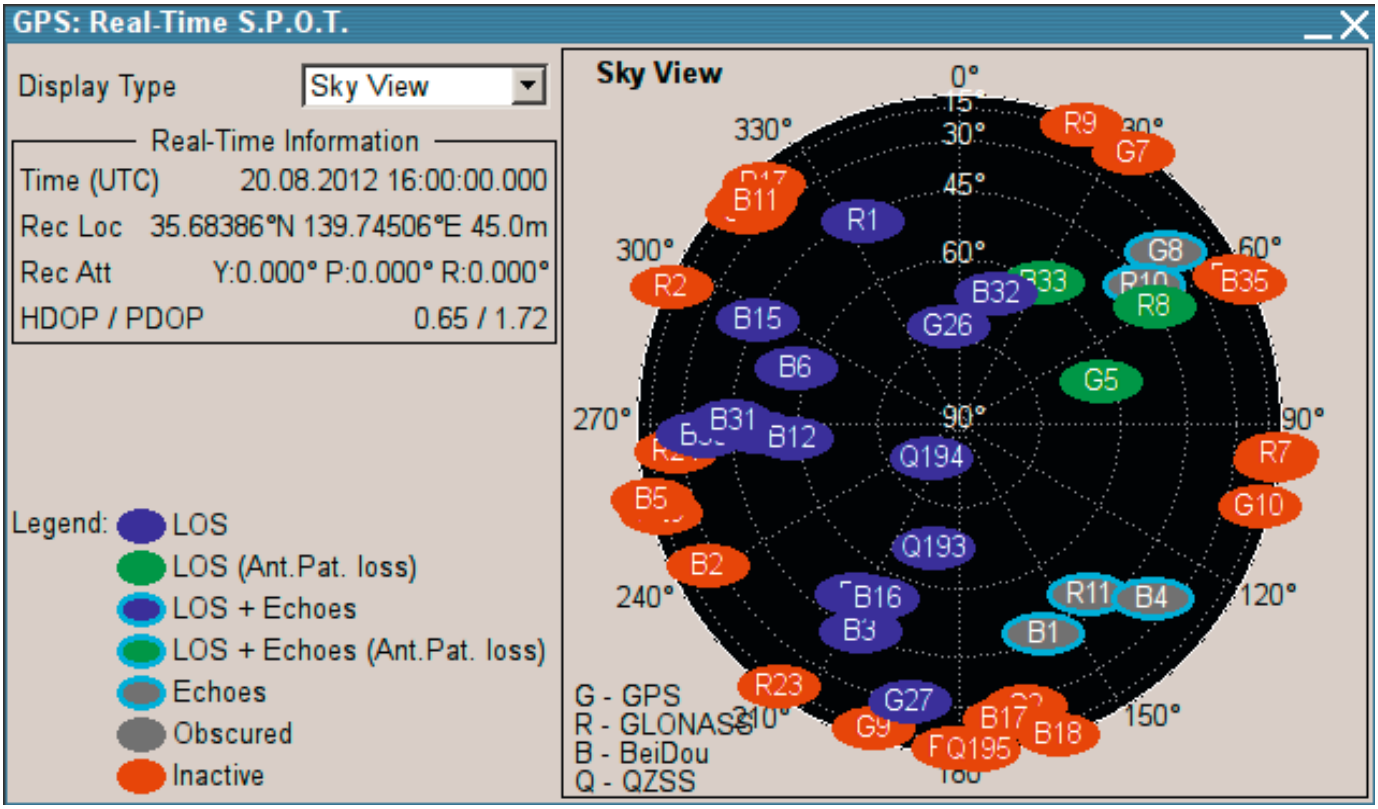
Simulation of a combined GPS/Glonass/Galileo/BeiDou/QZSS constellation with consideration of signal obscuration and multipath.



GNSS receiver tests made easy

Whether measuring TTFF, location accuracy, reacquisition time or sensitivity: With the GNSS simulator solution in the R&S®SMBV100A, the performance of receivers is quickly and easily characterized.

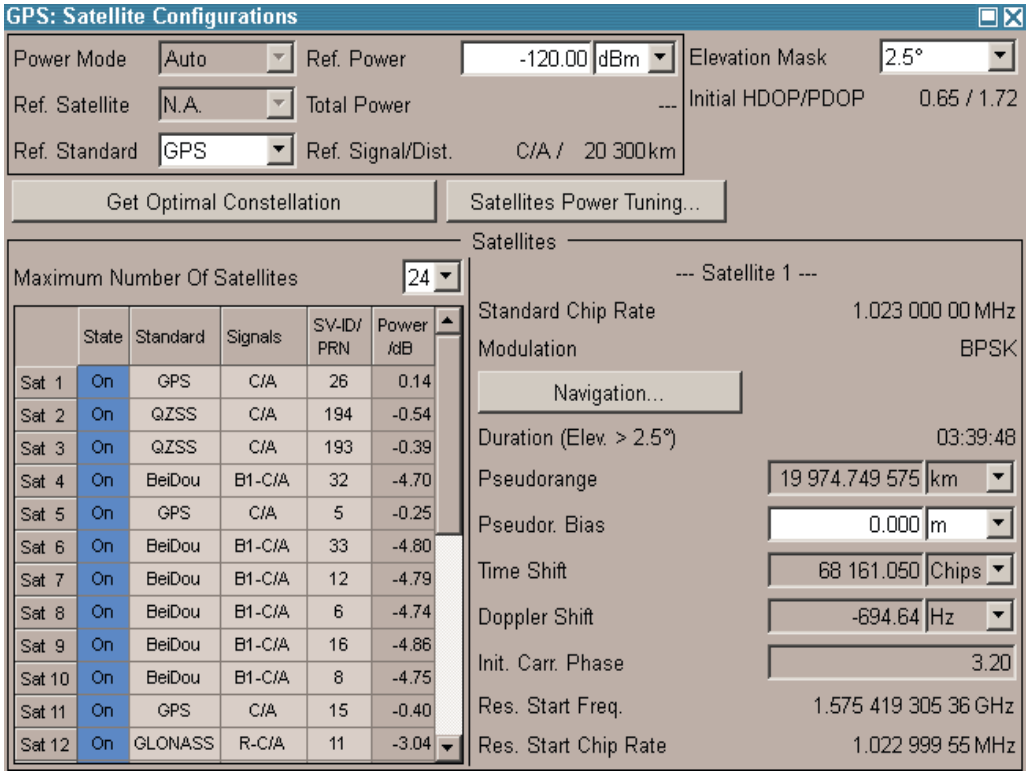
Flexible scenario generation facilitates receiver testing

A number of standard tests are available for characterizing the performance of a GNSS receiver, including TTFF, location accuracy and sensitivity tests. Entire test series are usually required before statistically solid statements can be made about the characteristics of a receiver. Each test in the series can be based on a different scenario, i.e. different conditions under which the test takes place. For example, the number of visible satellites or the satellite signal strength can be varied in order to simulate scenarios where satellite visibility is restricted. Even the geographic position can be changed from test to test. While one scenario is based on a stationary position, another might be based on moving along a defined route (moving scenario).

Many GNSS simulators offer users only a defined number of precalculated scenarios for playback. But this usually does not meet the requirements and conditions described above. In contrast, the R&S®SMBV100A allows users to generate unlimited customized scenarios, making it easy to perform receiver tests under varying conditions.

Only a few keystrokes are needed in the R&S®SMBV100A user interface to generate complex scenarios with up to 24 satellites. Multistandard GNSS receivers are constantly increasing in importance. This is why the R&S®SMBV100A was designed to simultaneously generate GPS, Glonass, Galileo, BeiDou and QZSS/SBAS signals in hybrid constellations.

The R&S®SMBV100A simulates the movement of satellites in orbits according to a real almanac file containing real navigation data. Any SEM or YUMA almanac file can be loaded into the R&S®SMBV100A for this purpose. The user can define any start time or date as well as any geographic position for either a stationary or a moving scenario. A moving scenario can be defined as any route, such as a drive through downtown Rome. The path trajectory is specified either with a simple waypoint file or by importing NMEA files.



The R&S®SMBV100A generates hybrid GPS, Glonass, Galileo, BeiDou and QZSS satellite constellations with minimum position dilution of precision (PDOP).

Faster testing with GNSS signal generation in realtime

While other GNSS simulators in this performance and price category can merely play back precalculated signals, the R&S®SMBV100A actually generates signals in realtime. All parameters can be set internally in the instrument, effectively eliminating the need for time-intensive recalculation of the signal using external PC software. As a result, users can change settings on the fly, which allows them to quickly and easily test the performance of a receiver under varying conditions.

Static simulations with zero or constant Doppler shifts for rapid receiver prototyping and development

When implementing signal processing algorithms in GNSS receivers, simplified signals are frequently required for verification tests. Especially for signal acquisition and the implementation of code- and phase-locked loops, it can be helpful to use static signals, i.e. signals without any Doppler shift.

The R&S®SMBV100A can be set to an appropriate mode (static mode) that is based on static (nonmoving) satellites and a static user. The signals generated this way do not exhibit any signal dynamics. Alternatively, constant Doppler shifts can be applied to the signals in order to simulate defined signal dynamics. Moreover, the navigation data stream can be matched to the test requirements and deactivated or modified as required.

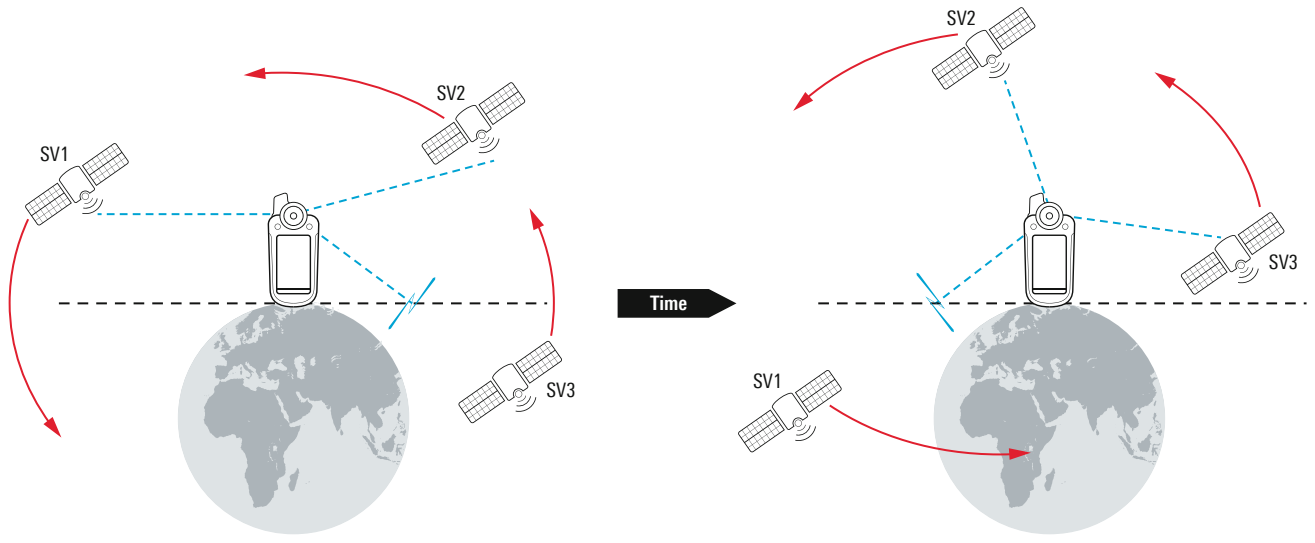
Unlimited simulation time with automatic, on-the-fly exchange of satellites

Some receiver tests require particularly long simulation times – for example, a moving scenario that simulates a drive from Frankfurt to Munich, or a stationary scenario that runs over several hours or even days in order to characterize the long-term stability of the receiver.

During such long simulation runs, some satellites move toward the horizon and disappear from sight while others rise into view. In auto localization mode, the R&S®SMBV100A automatically handles the satellites' risings and settings, so that GNSS signals are available as long as needed or throughout the entire simulation run.

The set of satellites to be simulated is continually calculated based on the number of available channels, the satellite visibility and the constellation geometry. The satellite visibility can be influenced by the user by configuring an elevation mask. The constellation geometry is optimized so that the set of simulated satellites results in a minimum position dilution of precision (PDOP) value.

For a given user position, some satellites drop below the horizon while others rise into view



Support of Assisted GNSS (A-GNSS) test cases for GPS, Glonass, Galileo, BeiDou and QZSS

Many modern mobile phones are equipped with A-GNSS functionality. To allow the integrated GNSS receiver to get a faster position fix when it is turned on, A-GNSS capable mobile phones retrieve their navigation data from the mobile radio network instead of decoding it from the satellite signal. This process is typically much faster and can reduce the TTFF from a worst case of several minutes to just a few seconds. This speed advantage is utilized for emergency functions, for example.

The R&S®SMBV100A supports all GNSS scenarios for A-GNSS test cases currently defined for GSM, 3GPP FDD and 3GPP2 (CDMA2000®). All necessary settings in the generator are made automatically. In addition to these predefined scenarios, custom scenarios can also be generated to implement user-defined A-GNSS test cases. In both cases, the associated assistance data can be generated automatically at the push of a button. The assistance data contains all navigation data needed by the A-GNSS capable mobile phone for faster position fixing. In reality, nearby base stations transfer the assistance data to the mobile phone. This is why a complete A-GNSS test setup includes the satellite simulator plus a radiocommunications tester like the R&S®CMW500 for simulating the role of the mobile radio network. The assistance data generated by the R&S®SMBV100A can be transmitted to the radiocommunications tester, so that it can in turn be made available to the DUT via a mobile radio connection.

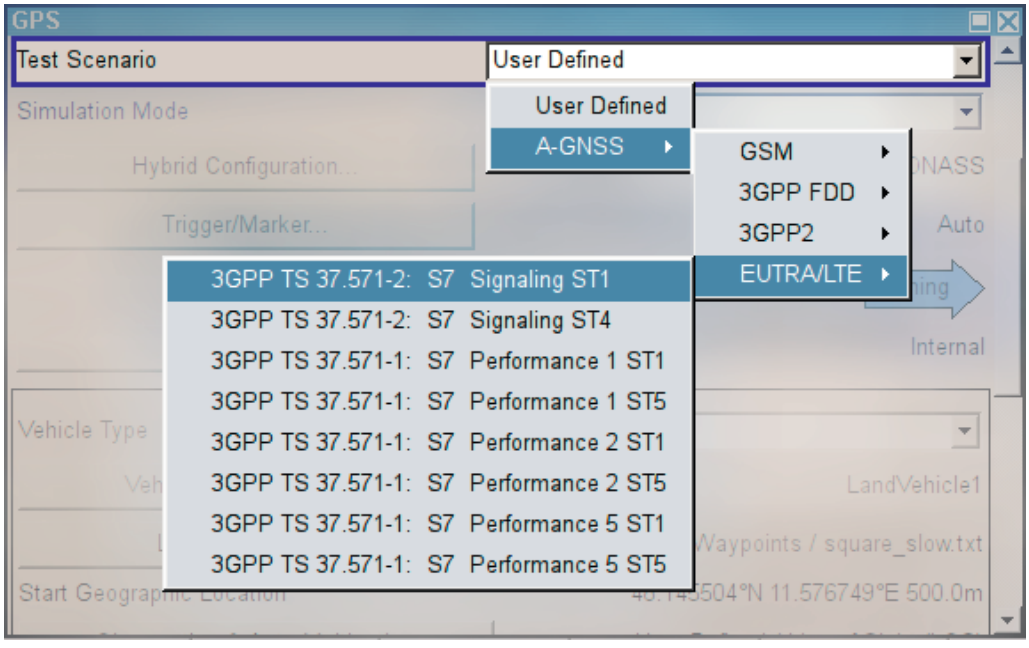
Aerospace and defense applications

In addition to the coarse/acquisition (C/A) code commercially used in GPS receivers, many applications, especially US military applications, require the P code. Due to its higher code rate, the use of a P code signal can significantly improve the positioning accuracy of a GNSS receiver.

The R&S®SMBV100A supports up to 12 satellites generating both the C/A and the P code signal. The signal generator automatically makes the necessary settings for the different code rates. All receiver tests in all modes of operation (static, auto localization, user localization), as well as moving receiver tests are fully supported in conjunction with P code simulations. The R&S®SMBV100A also supports pure P code signals for testing military GPS receivers.

The R&S®SMBV100A supports simulations with high signal dynamics even in the standard version. Speeds of up to 599 m/s and accelerations of up to 160 g can be simulated for a moving user. For special A&D applications, the available speed range can be extended to 10 000 m/s using a hardware option1). This makes it possible to simulate movements of supersonic and hypersonic aircraft, for example. Another A&D application involves the simulation of spinning vehicles, which is also possible with the R&S®SMBV100A. In addition, the R&S®SMBV100A supports ground-based augmentation system (GBAS) simulations by providing a VHF signal containing GBAS messages that can be fed to a GBAS receiver under test.

1) May be subject to export restrictions.



All currently defined GPS scenarios for A-GNSS test cases are implemented in the R&S®SMBV100A.

Support of hardware-in-the-loop applications through realtime external trajectory feed

The R&S®SMBV100A can simulate a moving user in various ways, e.g. by applying predefined trajectories as those used for the simulation of 3GPP test scenarios. Alternatively, trajectories can be defined in the form of waypoints, or they can be imported and played back using routes that were recorded in NMEA format with a GNSS receiver.

Another approach to motion simulation is to feed externally generated trajectories (i.e. from outside the R&S®SMBV100A) via SCPI to the R&S®SMBV100A. This makes it possible to simulate complex HIL applications with high update rates and extremely low latencies.

Simulation of real-world conditions

Ionospheric effects, tropospheric influences, signal obscuration and multipath effects are among the key factors that can impact the quality and availability of GNSS signals. Using the R&S®SMBV100A, such influences can be quickly and easily configured to obtain a realistic simulation of receiving conditions.

Ensuring realistic conditions for receiver tests

Receiver tests can only be conclusive when they are performed under realistic conditions. Therefore, the simulation must take into consideration the signal propagation characteristics, the properties of the receive antenna and the receiver environment. Realistic modeling of user movement taking into account the angles of attitude is also part of this simulation process.

The R&S®SMBV100A makes it possible to model such influences. Atmospheric influences, multipath propagation and signal obscuration due to buildings, antenna patterns and vehicle movements can be easily configured and simulated. In this way, complex yet reproducible scenarios can be created to completely characterize a GNSS receiver under test.

Simulation of atmospheric effects

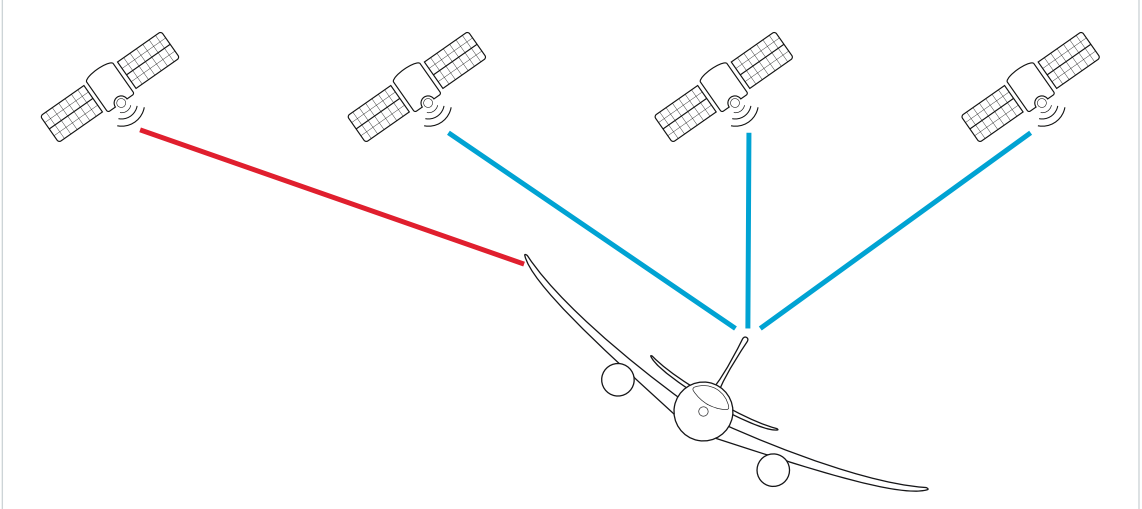
The R&S®SMBV100A is capable of simulating delays due to ionospheric and tropospheric influences. The user can adapt, modify or deactivate such delays using the corresponding configuration parameters.

Customizable antenna characteristics

Receive antennas generally do not exhibit an omnidirectional reception pattern. Instead, the reception pattern depends on the signal's angle of arrival.

Using the R&S®SMBV100A, antenna patterns can be user-defined as a function of the azimuth and elevation of the arriving signals. The antenna gain can be configured, and changes in the signal's phase angle can be taken into account. Moreover, it is possible to configure signal obscuration caused, for example, by aircraft wings or within a vehicle due to vehicle body parts. The antenna can be positioned at any point on the vehicle relative to the vehicle's center of mass.

Simulation of realistic trajectories with consideration of vehicle attitude and signal obscuration due to vehicle body parts



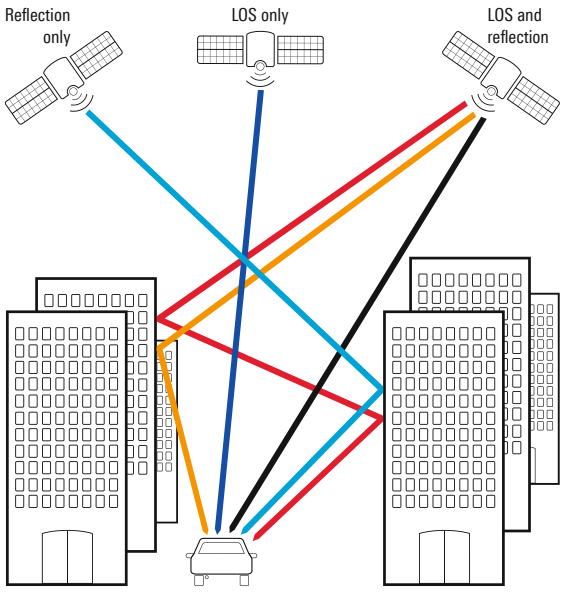
Realistic vehicle dynamics, including attitude simulation

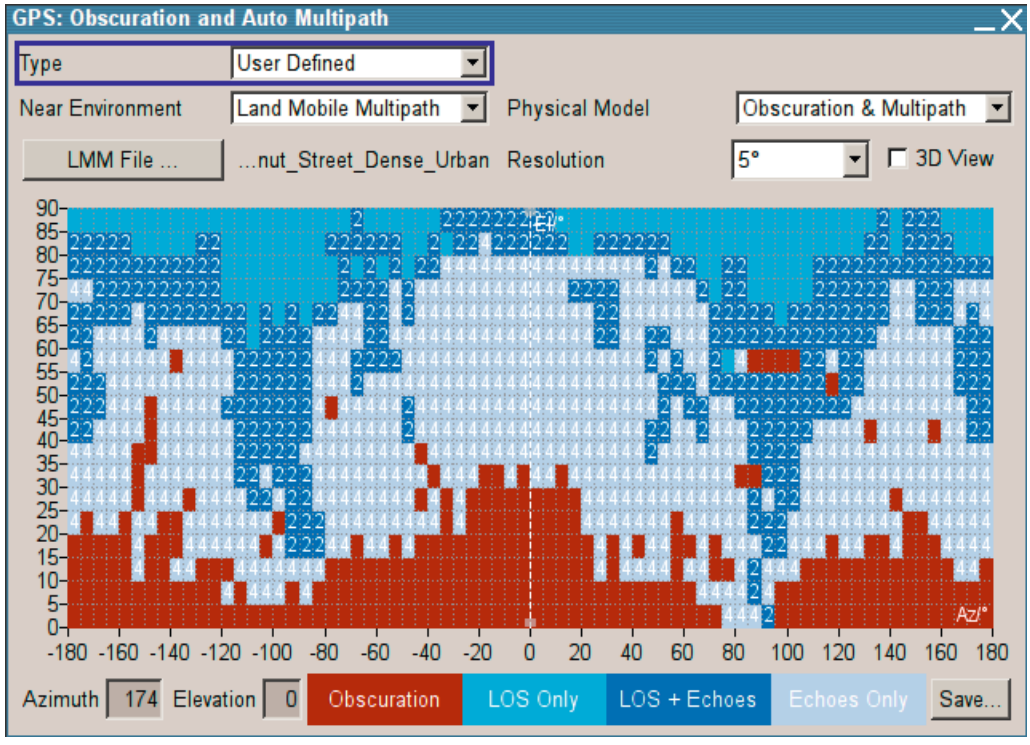
The R&S®SMBV100A enables realistic simulation of vehicle movement. Based on the vehicle type as well as the trajectory to be simulated, the vehicle attitude is precisely modeled and the corresponding (roll/bank, pitch/elevation, yaw/heading) angles are simulated. In conjunction with the defined antenna pattern, the exact vehicle attitude determines the signal strength and visibility of the arriving signals. For example, signals at certain roll/bank angles are obscured by an aircraft's wings.

Urban canyon simulations with multipath and signal obscuration

In many cases, the satellite signals do not reach the receive antenna directly. Instead, they are reflected by buildings, trees or the ground. Compared to the direct signal, multipath signals of this kind arrive later at the antenna and exhibit loss, which can cause significant positioning errors. The magnitude of such positioning errors ultimately depends on the multipath characteristics and especially the signal processing in the receiver. To efficiently test a receiver's internal multipath mitigation techniques, highly realistic and reproducible simulation of multipath signals is mandatory.

Urban canyon simulation





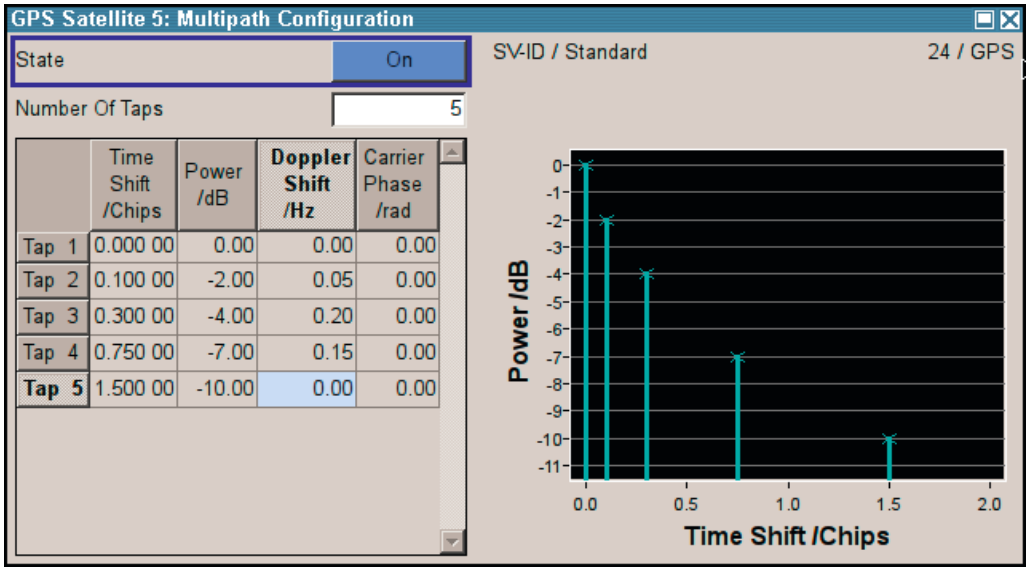
Configuration of a land mobile multipath environment. Line of sight signals, echoes and signal obscuration can be configured as a function of the signals' azimuth and elevation angles.

The R&S®SMBV100A offers extensive configuration capabilities for simulating multipath signals. A number of suitable models are available ranging from simple manual definition of multiple indirect paths per satellite signal to automatic generation of ground reflections and simulation of complex multipath environments, including signal obscuration. Simulation of urban canyon environments also plays a key role, because signal availability and signal quality in these canyons are heavily affected by multipath propagation and obscuration.

The R&S®SMBV100A offers a selection of preconfigured environments, which can be modified with a built-in editor. All relevant multipath signals and obscuration effects due to buildings can be automatically calculated and simulated based on the building geometry, user movement and surface characteristics. In this way, trips through inner-city areas as well as influences of highway bridges or tunnels can be easily simulated.

Configurable noise and interference simulation

Since the R&S®SMBV100A can be equipped with an internal noise generator, defined noise can be superimposed on the GNSS signals. Alternatively, the same device can be used to simulate a CW interferer with configurable spacing from the GNSS carrier and configurable signal strength. Using a second device, user-defined interference signals can be generated and additional scenarios implemented, e.g. simultaneous reception of GPS and Bluetooth® or WLAN.



The R&S®SMBV100A allows several multipath taps per satellite to be defined.

Customized solutions through flexible options

6, 12 or 24 satellites? GPS, Glonass, Galileo, BeiDou and/or QZSS/SBAS? GPS C/A code or P code? With or without moving scenarios? The GNSS solution for the R&S®SMBV100A makes it possible: Users can completely customize their solution.

Instrument configuration tailored to customer needs

Users of the R&S®SMBV100A do not have to pay for features that they might never use. The instrument configuration can be expanded to include specific features as test requirements change. Because additional functionality is released via software license keys, there are no downtimes for time-consuming hardware installations. Users can continue working without interruption.

Ready for other GNSS standards

The market for GNSS has grown steadily over the last few years. Especially with new satellite systems such as the Chinese BeiDou and the Indian IRNSS currently being under development and existing systems being modernized, the variety of available satellite systems, signals and applications will continue to grow.

To take this development into account, the R&S®SMBV100A is ready to support other satellite standards above and beyond GPS, Glonass, Galileo, BeiDou and QZSS/SBAS. This is made possible by the powerful R&S®SMBV100A hardware platform coupled with the very generic software architecture of the GNSS solution, making the R&S®SMBV100A a very safe investment for the future.

Ideal for production and R&D alike

The flexible GNSS options allow the R&S®SMBV100A to be configured according to the users' needs so that it can be used both in production and in the R&D lab. Users do not have to learn to work with a number of different instruments or simulation approaches; one instrument will meet all simulation requirements and provides a powerful, flexible and intuitive user interface. Automated simulations can be set up easily using a comprehensive set of remote control commands.

The GPS, Glonass, Galileo, BeiDou and QZSS/SBAS options (R&S®SMBV-K44, R&S®SMBV-K94, R&S®SMBV-K66, R&S®SMBV-K107, R&S®SMBV-K105 and R&S®SMBV-K110) already support a number of R&D applications. For example, when integrating GNSS modules into mobile phones, these options allow complete receiver tests, such as TTFF (under cold, warm or hot start conditions), location accuracy and reacquisition time, with up to 6 dynamic satellites. Installing the GPS, Glonass, Galileo, BeiDou and/or QZSS/SBAS options together in a single instrument permits hybrid constellations with up to 6 satellites for easily carrying out tests on multistandard receivers.

By adding the R&S®SMBV-K92 software option, the existing solution can be expanded to handle the above tests in a moving scenario instead of a static scenario, to perform the tests under less-than-ideal transmission conditions (e.g. in a multipath environment) or to use the external trajectory feed to set up hardware-in-the-loop tests. The R&S®SMBV-K91 software option allows the number of satellites to be increased up to 12. Using the R&S®SMBV-K96 software option, even 24 satellites can be simulated simultaneously.

Other software options are available to flexibly extend the configuration capabilities of the user environment according to test requirements. The R&S®SMBV-K101 option allows users to configure and simulate an urban environment containing buildings for which signal reflections and obscuration are automatically calculated and simulated. The R&S®SMBV-K102 option makes it possible to configure receive antenna properties such as antenna gain, phase shift and obscuration due to vehicle body parts. The R&S®SMBV-K103 option enhances the broad scope of R&S®SMBV100A functions by offering realistic trajectory simulation with consideration of the vehicle's roll/bank, pitch/elevation and yaw/heading angles, as well as simulation of spinning vehicles.

GNSS simulation plus multifaceted vector signal generation

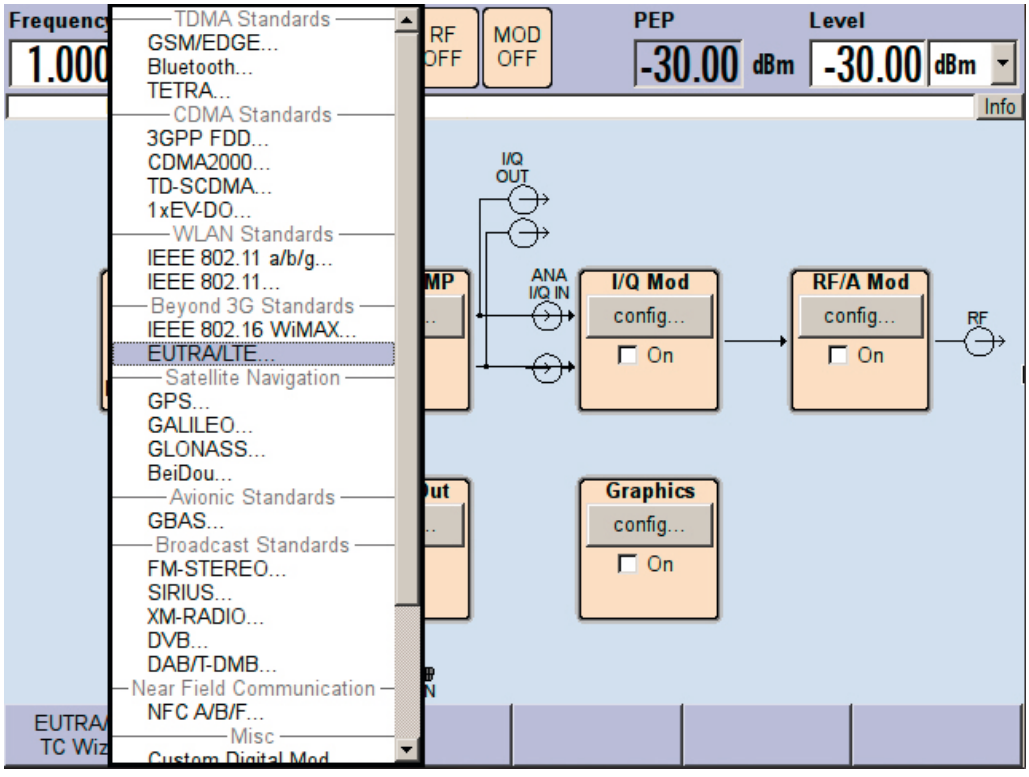
The R&S®SMBV100A is not just a satellite simulator, it is also a flexible vector signal generator with outstanding RF performance. This allows manufacturers of mobile phones or car infotainment systems to test both the main functionality of their products as well as the GNSS functionality with a single instrument.

Support of all important, state-of-the-art digital standards

Manufacturers who integrate GNSS modules into mobile phones or car infotainment systems have to test GNSS functionality in addition to their product's main functionality. Even increasing numbers of chips in GNSS standalone devices are being designed to handle multiple standards. At the very least, they often support Wi-Fi and Bluetooth® for updating maps or swapping route data.

This is where users particularly profit from the versatility of the R&S®SMBV100A. It allows them to test a range of functions with a single instrument because, in addition to GNSS signals, the R&S®SMBV100A can optionally generate standard-compliant signals for all important digital communications standards (LTE, HSPA+, WCDMA, WiMAX™, GSM, WLAN) and radio standards (DAB, Sirius|XM Satellite Radio, HD Radio™). With the internal baseband generator (R&S®SMBV-B10), all settings can be made directly on the instrument with no external software. This is especially advantageous in R&D applications where users need quick access to parameters without time-intensive recalculation of waveforms.

The R&S®SMBV100A can also play back precalculated signals, which are often used in production applications. For all of the standards listed above, the external R&S®WinIQSIM2™ software provides options that allow standard-compliant waveforms to be generated with only a few keystrokes.



The R&S®SMBV100A optionally supports a number of digital communications standards and analog/digital radio standards.

Customized internal signal generation

In addition to signal generation in accordance with digital standards, the baseband generator (R&S®SMBV-B10) provided by the R&S®SMBV100A also generates user-defined, digitally modulated signals. Again, signals can be generated either in realtime directly in the instrument, or they can be generated as a precalculated waveform using the R&S®WinIQSIM2™ software. Using the integrated ARB, the R&S®SMBV100A can also play back customized signals and special test vectors (e.g. generated with MATLAB®).

High performance for all types of applications

In addition to its flexibility with respect to signal generation, the R&S®SMBV100A also offers excellent RF performance, which is a prerequisite for pure signals and reproducible measurements.

For example, a key parameter for RF quality is SSB phase noise. This parameter is important for CW applications as well as for digital signals because it directly affects the error vector magnitude (EVM). The R&S®SMBV100A not only exhibits excellent SSB phase noise, it also boasts outstanding values for harmonic and nonharmonic suppression, which is also a significant factor in the quality of GNSS signals.

When testing GNSS receivers, one key parameter is the level range of the generator. This range must support the low levels required for sensitivity tests which determine the minimum level at which a receiver can acquire a signal or maintain a position fix. The R&S®SMBV100A allows a level of down to –145 dBm to be set with a resolution of 0.01 dB. This high resolution is needed to determine the sensitivity of the receiver as precisely as possible. The R&S®SMBV100A also offers excellent level accuracy for ensuring the reproducibility of the measurement results.

On the other hand, a powerful signal generator like the R&S®SMBV100A should also exhibit a sufficiently high output power for general applications, such as component tests. This makes it possible to compensate for loss between the generator and the DUT resulting from complex test setups (cables, switches, couplers, etc.) without having to use an external amplifier. As standard, the R&S®SMBV100A offers a specified output power of +18 dBm (PEP), and of more than +24 dBm in overrange.

GNSS options – overview in brief

The R&S®SMBV100A offers options related to the GNSS standard, such as the R&S®SMBV-K44 GPS base option or the R&S®SMBV-K66 Galileo base option, as well as standard-independent options. An example is the R&S®SMBV-K91 option which does not change the features of an individual satellite, but rather increases to 12 the number of GNSS satellites that can be simulated.

The following is a detailed overview of the available options and the functionality they provide.

GPS (R&S®SMBV-K44 option)

- Simulation of up to 6 GPS satellites with C/A code at frequencies L1 and L2
- Static mode and localization mode
- User-definable almanac file (SEM/YUMA) with real navigation data
- User-definable location and start time
- Automatic setup of GPS scenario with optimum satellite constellation
- Unlimited simulation time with automatic, on-the-fly exchange of satellites
- Dynamic power control of individual satellites in realtime
- Hybrid GNSS satellite constellations with up to 6 satellites (requires the R&S®SMBV-K66 Galileo, R&S®SMBV-K94 Glonass, R&S®SMBV-K105 QZSS, R&S®SMBV-K110 SBAS and/or R&S®SMBV-K107 BeiDou option)

Assisted GPS (R&S®SMBV-K65 option)

- Support of predefined and user-defined A-GPS test scenarios
- Generation of A-GPS assistance data for predefined and user-defined scenarios
- Fully user-defined configuration of GPS navigation message (manually or via import of RINEX ephemeris files)
- Requires the R&S®SMBV-K44 option

GPS P code (R&S®SMBV-K93 option)

- Simulation of up to 6 GPS satellites with P codes or combined civilian C/A and military P codes
- Requires the R&S®SMBV-K44 option
- Static mode and localization mode
- User-definable almanac file (SEM/YUMA) with real navigation data
- User-definable location and start time
- Automatic setup of GPS scenarios with optimum satellite constellation
- Unlimited simulation time with automatic, on-the-fly exchange of satellites
- Dynamic power control of individual satellites in realtime
- Hybrid GNSS satellite constellations with up to 6 satellites (requires the R&S®SMBV-K66 Galileo, R&S®SMBV-K94 Glonass, R&S®SMBV-K105 QZSS, R&S®SMBV-K110 SBAS and/or R&S®SMBV-K107 BeiDou option)

Galileo (R&S®SMBV-K66 option)

- Simulation of up to 6 Galileo satellites at frequency E1
- Static mode and localization mode
- User-definable almanac file (SEM/YUMA) with real navigation data
- User-definable location and start time
- Automatic setup of Galileo scenario with optimum satellite constellation
- Unlimited simulation time with automatic, on-the-fly exchange of satellites
- Dynamic power control of individual satellites in realtime
- Hybrid GNSS satellite constellations with up to 6 satellites (requires the R&S®SMBV-K44 GPS, R&S®SMBV-K94 Glonass, R&S®SMBV-K105 QZSS, R&S®SMBV-K110 SBAS and/or R&S®SMBV-K107 BeiDou option)

Assisted Galileo (R&S®SMBV-K67 option)

- Support of user-defined A-Galileo test scenarios
- Generation of A-Galileo assistance data
- Fully user-defined configuration of Galileo navigation message (manually or via import of RINEX ephemeris files)
- Requires the R&S®SMBV-K66 option

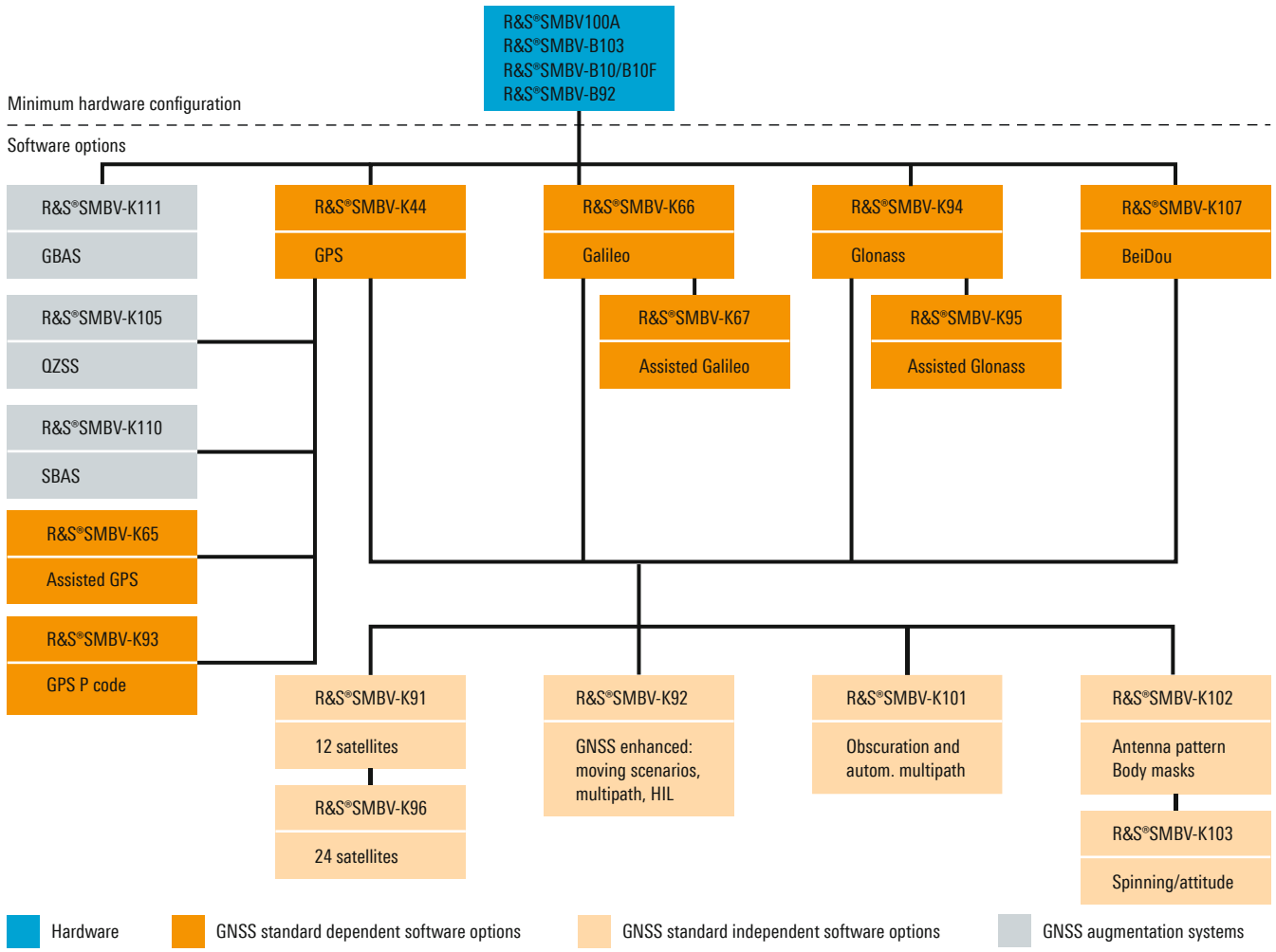
Glonass (R&S®SMBV-K94 option)

- Simulation of up to 6 Glonass satellites (FDMA) with civilian codes at frequencies L1 and L2
- Static mode and localization mode
- User-definable almanac file (.agl) with real navigation data
- User-definable location and start time
- Automatic setup of Glonass scenario with optimum satellite constellation
- Unlimited simulation time with automatic, on-the-fly exchange of satellites
- Dynamic power control of individual satellites in realtime
- Hybrid GNSS satellite constellations with up to 6 satellites (requires the R&S®SMBV-K44 GPS, R&S®SMBV-K66 Galileo, R&S®SMBV-K105 QZSS, R&S®SMBV-K110 SBAS and/or R&S®SMBV-K107 BeiDou option)

Assisted Glonass (R&S®SMBV-K95 option)

- Support of predefined and user-defined A-Glonass test scenarios
- Generation of A-Glonass assistance data for predefined and user-defined scenarios
- Fully user-defined configuration of Glonass navigation message (manually or via import of RINEX ephemeris files)
- Requires the R&S®SMBV-K94 option

R&S®SMBV100A option tree showing hierarchy and dependencies among GNSS options



BeiDou (R&S®SMBV-K107 option)

- Simulation of up to 6 BeiDou satellites at frequencies B1 and B2
- Static mode and localization mode
- User-definable almanac file with real navigation data
- D1 and D2 navigation messages for MEO/IGSO and GEO satellites, respectively
- User-definable location and start time
- Automatic setup of BeiDou scenario with optimum satellite constellation
- Unlimited simulation time with automatic, on-the-fly exchange of satellites
- Dynamic power control of individual satellites in realtime
- Hybrid GNSS satellite constellations with up to 6 satellites (requires the R&S®SMBV-K44 GPS, R&S®SMBV-K66 Galileo, R&S®SMBV-K105 QZSS, R&S®SMBV-K110 SBAS and/or R&S®SMBV-K94 Glonass option)

QZSS (R&S®SMBV-K105 option)

- Simulation of GPS C/A and QZSS C/A satellite signals with up to 6 satellites at frequency L1
- Static mode and localization mode
- User-definable almanac file (SEM/YUMA) with real navigation data
- User-definable location and start time
- Automatic setup of hybrid GPS/QZSS scenarios with optimum satellite constellation
- Unlimited simulation time with automatic, on-the-fly exchange of satellites
- Dynamic power control of individual satellites in realtime
- Hybrid GNSS satellite constellations with up to 6 satellites (requires additional R&S®SMBV-K66 Galileo option and/or R&S®SMBV-K94 Glonass option and/or R&S®SMBV-K107 BeiDou option)
- Requires the R&S®SMBV-K44 GPS option

SBAS (R&S®SMBV-K110 option)

- Simulation of GPS C/A and SBAS C/A satellite signals with up to 6 satellites at frequency L1
- Static mode and localization mode
- Support of EGNOS/WAAS/MSAS regional systems with up to 5 SBAS PRNs per system
- Support of ranging, correction and integrity services
- Support of user-definable SBAS configurations with XML formatted files and editing function for the graphical user interface
- Support of raw daily SBAS navigation data available on the EGNOS and WAAS FTP servers
- Unlimited simulation time with automatic, on-the-fly exchange of satellites
- Dynamic power control of individual satellites in realtime
- Requires the R&S®SMBV-K44 GPS option

GNSS extension to 12 satellites (R&S®SMBV-K91 option)

- Simulation of civilian signals from up to 12 GNSS satellites
- Requires the R&S®SMBV-K44, R&S®SMBV-K66, R&S®SMBV-K94, R&S®SMBV-K105 QZSS, R&S®SMBV-K110 SBAS and/or R&S®SMBV-K107 option

GNSS extension to 24 satellites (R&S®SMBV-K96 option)

- Simulation of GPS, Galileo, Glonass, BeiDou, QZSS and/or SBAS signals from up to 24 GNSS satellites
- Enhances the multipath budget of GPS C/A, Galileo, Glonass, BeiDou, QZSS and/or SBAS signals to 24 (requires additional R&S®SMBV-K92 option to enable multipath simulation capabilities)
- Requires the R&S®SMBV-K91 option

GNSS enhanced (R&S®SMBV-K92 option)

- WGS84 waypoint interface and import of NMEA waypoints
- Import of Google Earth and Google Maps .kml files
- East-North-Up (ENU) 2D vector trajectory interface (line, arc) for automatic waypoint generation
- Motion interface for dynamics input (velocity vector or velocity magnitude) in ENU and WGS84
- Predefined waypoint files for land vehicles, ships, aircraft and spacecraft
- User-definable and predefined vehicle description files for land vehicles, ships, aircraft and spacecraft
- Smoothing of waypoints using vehicle description files
- Hardware-in-the-loop (HIL) realtime feed of vehicle motion data (position, velocity, acceleration and jerk)
- Configurable HIL streaming rate of up to 100 Hz
- HIL execution synchronous to 1 PPS; 10 ms system response delay and applied prediction algorithms
- User-definable multipath
- Configurable atmospheric models
- Configurable system time transformation parameters
- Configurable leap second simulation
- Logging of simulation data
- Requires the R&S®SMBV-K44, R&S®SMBV-K66, R&S®SMBV-K94, R&S®SMBV-K105, R&S®SMBV-K110 and/or R&S®SMBV-K107 option

GNSS extension for obscuration simulation and automatic multipath (R&S®SMBV-K101 option)

- User-definable vertical obstacles to model urban environments
- User-definable roadside planes to model highway and cutting environments
- User-definable interface to model ground/sea reflection for aircraft and ships
- User-definable interface to model full signal obscuration as in tunnels
- Automatic realtime update of satellite visibility and multipath depending on the modeled user environment in auto localization mode
- 10 Hz obscuration and multipath environment sampling
- Configurable material property for vertical obstacles, roadside planes and ground/sea terrains
- Predefined environment models such as rural area, suburban area, urban canyon, tunnel, bridge, highway
- Customizable land mobile multipath environment
- Requires the R&S®SMBV-K44, R&S®SMBV-K66, R&S®SMBV-K94, R&S®SMBV-K105, R&S®SMBV-K110 and/or R&S®SMBV-K107 option
- Automatic multipath update requires R&S®SMBV-K92

GNSS extension for antenna pattern (R&S®SMBV-K102 option)

- User-definable models for antenna patterns and vehicle body masks
- Predefined body masks for land vehicles, ships, aircraft and spacecraft
- Automatic realtime update of satellite power and carrier phase depending on the antenna pattern and attitude parameters in auto localization mode
- 800 Hz satellite power and carrier phase update rate following antenna pattern
- Automatic attitude extraction from motion heading for automotive environments
- Simulation of up to four antenna patterns/body masks for a selected vehicle and their body offsets to the vehicle
- Realtime synchronous switch between antenna patterns by means of scheduling
- Requires the R&S®SMBV-K44, R&S®SMBV-K66, R&S®SMBV-K94, R&S®SMBV-K105, R&S®SMBV-K110 and/or R&S®SMBV-K107 option

GNSS extension for spinning and attitude (R&S®SMBV-K103 option)

- Configurable pitch/elevation, yaw/heading and roll/bank attitude parameters
- Predefined attitude profiles and movement files
- Up to 400 Hz spinning rate
- Realtime feed of motion and attitude data for HIL applications
- Requires the R&S®SMBV-K102 option

GBAS extension (R&S®SMBV-K111 option)

- Provision of GBAS messages via VHF link
- Simultaneous simulation of up to 11 GBAS frequency channels emulating multiple VHF data broadcast (VDB) towers
- Generation of message types 1, 2, 4 and 11
- Support of real GBAS data generation based on user-configurable waypoint file and differential GNSS data

R&S®SMBV100A with R&S®SMBV-P101 GNSS production tester

The R&S®SMBV-P101 GNSS production tester [1] was designed especially for GNSS chipset testing and speed-optimized production testing of GNSS receivers. It supports GPS, Glonass, BeiDou and Galileo. The GNSS production tester also supports additional measurements for characterizing GNSS chipsets. It provides flexibly customizable navigation data and movement profiles for verifying the maximum movement dynamics of a GNSS receiver.

[1] The R&S®SMBV-P101 package is a standalone, unchangeable instrument configuration. No other options are required.

Tailored for production testing

The R&S®SMBV100A with the R&S®SMBV-P101 option is tailored to meet the demands placed on a GNSS tester.

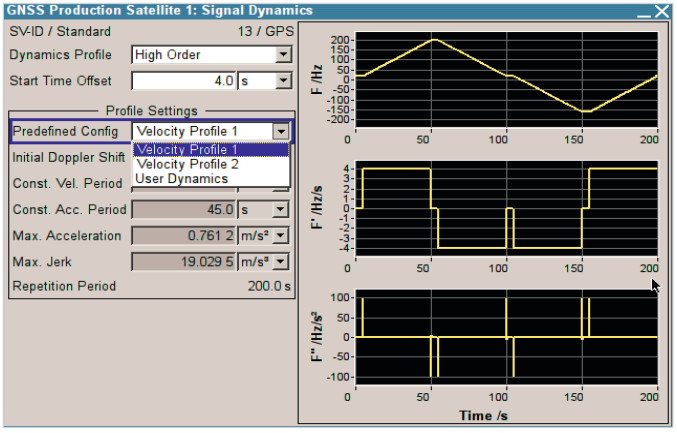
During production testing of GNSS modules and receivers, the basic GNSS signal reception and the connection between the antenna and GNSS chipset need to be checked. The GNSS production tester, based on the R&S®SMBV100A, simulates separate satellites for the GPS, Glonass, BeiDou and Galileo navigation standards in the L1/E1 bands. The four satellites can be activated individually, each with a dynamic range of 34 dB. Level changes can be made on the fly without interrupting the signal, enabling users to simultaneously perform independent sensitivity tests for each system. The large dynamic range provides sufficient margin to accommodate the variance in the chipsets. The 1 pps and 10 pps GNSS markers allow fast synchronization between the tester and DUT, enabling high throughput.

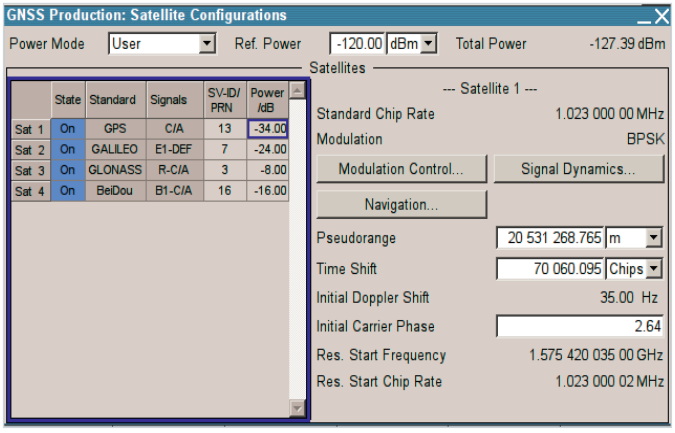
In addition to GNSS signals, the GNSS production tester can produce pure, level-stable CW signals for very basic tests to calibrate the setup with significantly higher levels or simply as an interferer.

Enhanced functions for characterization

Functions beyond the production test features are necessary to efficiently characterize GNSS chipsets. The required user data can be selected from data patterns, data lists or even real navigation data that is automatically generated from the almanac files in the GNSS tester. Zero navigation data is also provided – with the ephemeris data set to zero – in order to verify the different stages in the receiver. Full coding is used and the synchronization fields are set accordingly. Since the four satellite signals are generated in realtime, the navigation data can be transmitted with a realtime GNSS clock. The 1 pps or 10 pps marker is used to verify the exact time synchronization in the GNSS receiver.

To quickly, cost-effectively and efficiently verify the receiver's ability to handle high movement dynamics, both predefined and user-defined movement profiles can be run. Maximum values can be set for acceleration and jerk. The production tester in the R&S®SMBV100A automatically generates the corresponding satellite signal with the required Doppler profile.





Specifications in brief

Specifications of the full-featured GNSS simulator in brief [1]		
General settings		
Frequency		based on RF band and GNSS hybrid configuration
		user-selectable in entire frequency range
Output level		based on power mode and individual satellite power parameters
		user-selectable in entire output level range of the R&S®SMBV100A
GNSS hybrid configuration		hybrid GNSS constellation, e.g. 2 GPS satellites, 2 Glonass and 2 Galileo satellites possible if R&S®SMBV-K44, R&S®SMBV-K94 and R&S®SMBV-K66 are installed
Simulation modes		static mode, auto localization mode, user localization mode
Dynamics		
Pseudorange error (RMS)		±0.01 m
Max. relative velocity		599 m/s or 10000 m/s [2]
Max. relative acceleration		1600 m/s^2
Max. relative jerk		400 m/s^3 (as impulse)
GPS (R&S®SMBV-K44)		
GPS		6 satellites, in line with ICD-GPS-200 revision D
RF bands		L1/E1, L2
GPS P code (R&S®SMBV-K93)		
GPS		6 satellites, in line with ICD-GPS-200 revision D (antispoofing disabled)
RF bands		L1/E1, L2
Galileo (R&S®SMBV-K66)		
Galileo		6 satellites, in line with OS SIS ICD, E1 band
RF bands		L1/E1
Glonass (R&S®SMBV-K94)		
Glonass		6 satellites, in line with ICD-GLONASS Version 5.0
RF bands		L1/E1, L2
BeiDou (R&S®SMBV-K107)		
BeiDou		6 satellites, in line with BDS-SIS-ICD-B1I-1.0
RF bands		L1/E1, L2
QZSS (R&S®SMBV-K105)		
QZSS		6 satellites, GPS C/A and QZSS C/A, in line with IS-QZSS V1.5
RF bands		L1/E1
SBAS (R&S®SMBV-K110)		
SBAS		6 satellites, GPS L1 C/A and SBAS L1 C/A, in line with DO-229D
RF bands		L1/E1
Assisted GNSS (R&S®SMBV-K65/-K67/-K95)		
A-GNSS test scenarios		predefined A-GPS/A-Glonass test scenarios for GSM, 3GPP FDD, 3GPP2 and EUTRA/LTE
		user-definable
Generation of assistance data	content	almanac, ionosphere, navigation, UTC and acquisition files
	format	in comma separated values (CSV) format, for navigation file also in standard RINEX format
RINEX import		ephemeris subframes can be configured manually or imported from a RINEX file

Specifications of the full-featured GNSS simulator in brief [1)]

GNSS extension to 12 satellites (R&S®SMBV-K91)		
GNSS extension to 12 satellites		simulation of up to 12 GNSS satellites, e.g. 8 GPS and 4 Galileo satellites (if R&S®SMBV-K44 and R&S®SMBV-K66 are both installed) or 12 C/A + P satellites (if R&S®SMBV-K44 and R&S®SMBV-K93 are both installed)
GNSS extension to 24 satellites (R&S®SMBV-K96)		
GNSS extension to 24 satellites		simulation of up to 24 GPS C/A, Galileo and/or Glonass satellites, e.g. 12 GPS C/A, 8 Galileo E1 and 4 Glonass satellites (if R&S®SMBV-K44, R&S®SMBV-K66 and R&S®SMBV-K94 are also installed)
GNSS enhanced (e.g. moving scenarios, multipath) (R&S®SMBV-K92)		
Moving scenario	available in auto localization mode and user localization mode	minimum duration of 12 hours before waypoint repetition; up to 4 days if R&S®SMBV-K511 is installed; up to 16 days if R&S®SMBV-K512 is installed
	supported formats	CSV, NMEA, proprietary
Waypoint smoothing		trajectory and vehicle dynamics smoothing based on a selected vehicle description file
Realtime waypoint feed		hardware-in-the-loop realtime feed of vehicle motion data; streaming rate up to 100 Hz; 10 ms system response delay
Atmospheric configuration		configuration of the ionospheric navigation parameters as they will be transmitted in the navigation message
		ionospheric and tropospheric models used in channel simulation
Multipath (satellite taps can be defined separately for each satellite; additional time shift, power, Doppler shift and carrier phase can be defined separately for each satellite tap)		
Channel budget	GPS, Glonass, Galileo, BeiDou, QZSS, SBAS	24 channels (with R&S®SMBV-K96)
Number of multipath taps		1 to 10 depending on remaining channel budget
Logging of simulation data		logging of user motion and attitude parameters
GNSS extension for obscuration simulation and automatic multipath (R&S®SMBV-K101)		
Obscuration and automatic multipath	available in auto localization mode and user localization mode	user-definable as well as predefined user environments (rural, suburban, urban canyon, tunnel, bridge, highway)
Land mobile multipath	available for pedestrians and land vehicles	elevation/azimuth grid with 4 possible states: ▪ obscuration ▪ line of sight ▪ line of sight and echoes ▪ echoes only
Number of channels		see R&S®SMBV-K92 data sheet; automatic selection of multipath signals based on elevation, multipath relative delay and amplitudes in case of insufficient number of channels
Update rate	depends on simulated multipath/obscuration environment	5 Hz to 10 Hz
Physical model		
Obscuration and multipath	requires R&S®SMBV-K92	simulates satellite visibility and multipath depending on a modeled user environment
Obscuration only		simulates satellite visibility depending on a modeled user environment; multipath not simulated
GNSS extension for antenna pattern (R&S®SMBV-K102)		
Antenna pattern/body mask	available in auto localization mode and user localization mode	simulates signal power and carrier phase response due to antenna pattern and body mask
Number of antenna patterns		1 to 4
Antenna pattern switching		possible through realtime scheduling
GNSS extension for spinning and attitude (R&S®SMBV-K103)		
Spinning and attitude	available in auto localization mode and user localization mode	allows the configuration of the vehicle's angular body parameters (attitude)
Attitude files	requires R&S®SMBV-K92	minimum duration of 12 hours before attitude repetition; up to 4 days if R&S®SMBV-K511 is installed; up to 16 days if R&S®SMBV-K512 is installed

Specifications of the full-featured GNSS simulator in brief [1]		
Attitude smoothing	requires R&S®SMBV-K92	vehicle attitude smoothing based on a selected vehicle description file
Realtime attitude feed	requires R&S®SMBV-K92	hardware-in-the-loop realtime feed of vehicle attitude data; streaming rate up to 100 Hz; 10 ms system response delay
Spinning		simulates a constant rate of change of roll
Spinning rate		up to 400 Hz
GBAS		in line with RTCA DO-246D
VHF data broadcast (VDB) tower configuration		
Number of VDB transmitters		generation of up to 8 VDB tower signals
Frequency number		–5 to 5
GBAS message configuration		
Message types	all messages can be modulated simultaneously if needed	message types 1, 2, 4 and 11
Waypoint file		used to load the TAP waypoint data modulated with GBAS message 4
Differential GNSS file		used to transmit differential GNSS corrections for GPS, Glonass and SBAS satellites in view

[1] These specifications in brief relate to the GNSS functionality of the R&S®SMBV100A. For specifications on the general performance of the R&S®SMBV100A or on the functionality of other digital standards, see the R&S®SMBV100A data sheet (PD 5214.1114.22) and the Digital Standards for Signal Generators data sheet (PD 5213.9434.22).

[2] Depending on hardware option; may be subject to export restrictions.

Specifications of the R&S®SMBV-P101 GNSS production tester in brief (standalone package)		
Systems and signals		
GNSS system frequencies		1575.42 MHz (GPS L1, Galileo E1), 1602.00 MHz (Glonass L1), 1561.098 MHz (BeiDou L1)
Supported GNSS		GPS, Glonass, Galileo, BeiDou
Supported signals	1575.42 MHz (L1)	single GPS, C/A code modulation, in line with IS-GPS-200F (Sept. 2011), PRN 1-32
	1602.00 MHz (L1)	single Glonass, C/A code modulation, in line with Glonass ICD version 5.1 (2008), frequency channel numbers –7 to +6
	1575.42 MHz (E1)	single Galileo, E1-B and E1-C signal, in line with Galileo ICD (Sept. 2010), PRN 1-50
	1561.098 MHz (L1)	single BeiDou, BeiDou B1 signal, in line with BeiDou ICD version 2.0 (Dec. 2013), PRN 1-37
Max. number of simulated signals	1 channel per simulated GNSS	4
Signal and data configuration		
Satellite relative power	configurable in user power mode	on/off
Ranging code per satellite		on/off
Navigation data per satellite		all 0
Navigation data source	identical for each satellite	all 1
		pattern (up to 64 bit)
		PN 9 to PN 23
		data lists
		real navigation data: almanac file as source for ephemeris and almanac subframes; ephemeris subframes are projected from the almanac subframes
		zero navigation data: navigation payload is set to zero; channel coding and synchronization fields are applied
Meander code for Glonass		on/off
Time mark for Glonass		on/off
Secondary code for BeiDou		on/off
Secondary code for Galileo		on/off

Specifications of the R&S®SMBV-P101 GNSS production tester in brief (standalone package)		
System time basis		GPS, UTC default: GPS
Simulation time		flexible date and time or GPS time configuration with a resolution of 1 ms
Marker		1 PPS
		1 PP2S
		10 PPS
		pulse
		pattern
		on/off ratio
		trigger
Doppler settings		
Constant Doppler (configurable per satellite)		
Doppler setting unit		m/s or Hz
Doppler setting range	Hz	±100 kHz
Doppler resolution	Hz	0.01 Hz
	m/s	0.01
Velocity/Doppler profiles		
Configurable profiles per satellite		defined by the following configurable parameters: ▪ max. jerk ▪ max. acceleration ▪ duration of constant acceleration ▪ duration of constant velocity (Doppler)

Ordering information

Full-featured GNSS simulator in the R&S®SMBV100A vector signal generator

Designation	Type	Order No.
Base unit (including power cable, quick start guide and CD-ROM, with operating and service manual)		
Vector Signal Generator [1]	R&S®SMBV100A	1407.6004.02
Hardware options (GNSS-related configuration) [2]		
Frequency Range 9 kHz to 3.2 GHz	R&S®SMBV-B103	1407.9603.02
Baseband Generator with digital modulation (realtime) and ARB (32 Msample), 120 MHz RF bandwidth	R&S®SMBV-B10	1407.8607.04
Baseband Generator with high signal dynamics, digital modulation (realtime) and ARB (32 Msample) [3], 120 MHz RF bandwidth	R&S®SMBV-B10F	1419.2009.02
Hard Disk (removable)	R&S®SMBV-B92	1407.9403.02
Memory Extension for ARB to 256 Msample (requires the R&S®SMBV-B92 option)	R&S®SMBV-K511	1419.2544.02
Memory Extension for ARB to 1 Gsample	R&S®SMBV-K512	1419.2567.02
Software options (GNSS-related only) [2]		
GPS	R&S®SMBV-K44	1415.8060.02
Assisted GPS	R&S®SMBV-K65	1415.8560.02
Galileo	R&S®SMBV-K66	1415.8590.02
Assisted Galileo	R&S®SMBV-K67	1419.2509.02
GNSS Extension to 12 Satellites	R&S®SMBV-K91	1415.8577.02
GNSS Enhanced (e.g. moving scenarios, multipath)	R&S®SMBV-K92	1415.8583.02
GPS P Code	R&S®SMBV-K93	1415.8660.02
Glonass	R&S®SMBV-K94	1415.8677.02
Assisted Glonass	R&S®SMBV-K95	1419.2521.02
GNSS Extension to 24 Satellites	R&S®SMBV-K96	1415.8790.02

Designation	Type	Order No.
GNSS Extension for Obscuration and Automatic Multipath	R&S®SMBV-K101	1415.8802.02
GNSS Extension for Antenna Pattern	R&S®SMBV-K102	1415.8819.02
GNSS Extension for Spinning and Attitude	R&S®SMBV-K103	1415.8825.02
QZSS	R&S®SMBV-K105	1419.2350.02
BeiDou	R&S®SMBV-K107	1419.2709.02
SBAS	R&S®SMBV-K110	1419.2373.02
GBAS	R&S®SMBV-K111	1419.2396.02
Recommended extras		
Hardcopy manuals (in English, UK)		1407.6062.32
Hardcopy manuals (in English, US)		1407.6062.39
19" Rack Adapter	R&S®ZZA-S334	1109.4487.00
Power Sensor, 9 kHz to 6 GHz	R&S®NRP-Z92	1171.7005.02
USB Serial Adapter for RS-232 remote control	R&S®TS-USB1	6124.2531.00
Accessories		
Documentation of Calibration Values	R&S®DCV-2	0240.2193.18
DAkkS (formerly DKD) Calibration in line with ISO 17025 and ISO 9000	R&S®SMBV-DKD	1415.8448.02

R&S®SMBV-P101 GNSS production tester (standalone package)

Designation	Type	Order No.
Vector Signal Generator	R&S®SMBV100A	1407.6004.02
GNSS Production Tester [4]	R&S®SMBV-P101	1419.2844.02

[1] The base unit can only be ordered with an R&S®SMBV-B10x frequency option.
[2] For additional options, see the R&S®SMBV100A data sheet (PD 5214.1114.22) and www.rohde-schwarz.com.
[3] Subject to export control regulations and therefore not available in all countries nor to all customers.
[4] No options can be added to this instrument configuration.

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For data sheet, see PD 5214.5284.22 and www.rohde-schwarz.com

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Rohde&Schwarz GmbH&Co. KG
www.rohde-schwarz.com

Regional contact

- Europe, Africa, Middle East | +49 89 4129 12345
  customersupport@rohde-schwarz.com
- North America | 1 888 TEST RSA (1 888 837 87 72)
  customer.support@rsa.rohde-schwarz.com
- Latin America | +1 410 910 79 88
  customersupport.la@rohde-schwarz.com
- Asia Pacific | +65 65 13 04 88
  customersupport.asia@rohde-schwarz.com
- China | +86 800 810 82 28 | +86 400 650 58 96
  customersupport.china@rohde-schwarz.com

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GNSS Simulator in the R&S®SMBV100A Vector Signal Generator
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